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DESIGN AND OPERATION OF ENERGY-AWARE WIRELESS SENSOR NETWORKS THROUGH SCHEDULING AND ROUTING

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Abstract: ***Self-configuring wireless sensor networks can be invaluable in many civil and military applications for collecting, processing, and disseminating wide ranges of complex environmental data. Because of this, they have attracted considerable research attention in the last few years.***
The WINS [1] and SmartDust [2] projects, for instance, aim to integrate sensing, computing,and wireless communication capabilities into a small form factor to enable low-cost production of these tiny nodes in large numbers. Several other groups are investigating efficient hardware/software system architectures, signal processing algorithms,and network protocols for wireless sensor networks [3]-[5].
Sensor nodes are battery driven and hence operate on an extremely frugal energy budget. Further, they must have a lifetime on the order of months to years, since battery replacement is not an option for networks with thousands of physically embedded nodes. In some cases, these networks may be required to operate solely on energy scavenged from the environment through seismic, photovoltaic, or thermal conversion. This transforms energy consumption into the most important factor that determines sensor node lifetime.
Keywords: *Scheduling and Routing Protocols, Wireless Sensor Network, Medium Access Control, TDMA, Clustering, Radio,etc..*

1. INTRODUCTION

Conventional low-power design techniques [6] and hardware architectures only provide point solutions which are insufficient for these highly energy-constrained systems. Energy optimization, in the case of sensor networks, is much more complex, since it involves not only reducing the energy consumption of a single sensor node but also maximizing the lifetime of an entire network. The network lifetime can be maximized only by incorporating energy awareness into every stage of wireless sensor network design and operation, thus empowering the system with the ability to make dynamic tradeoffs between energy consumption, system performance, and operational fidelity. This new networking paradigm, with its extreme focus on energy efficiency, poses several system and network design challenges that need to be overcome to fully realize the potential of these wireless sensor systems. Sensor networks offer a powerful combination of distributed sensing, computing and communication.

They lend themselves to countless applications and, at the same time, offer numerous challenges due to their peculiarities, primarily the stringent energy constraints to which sensing nodes are typically subjected. The distinguishing traits of sensor networks have a direct impact on the hardware design of the nodes at at least four levels: power source, processor, communication hardware, and sensors. Various hardware platforms have already been designed to test the many ideas spawned by the research community and to implement applications to virtually all fields of science and technology. We are convinced that CAS will be able to provide a substantial contribution to the development
of this exciting field.

2. POWER CONSUMPTION PERSPECTIVE:

The first step in designing energy-aware sensor systems involves analyzing the power dissipation characteristics of a wireless sensor node. Systematic power analysis of a sensor node is extremely important to identify power bottlenecks in the system, which can then be the target of aggressive optimization. We analyze two popular sensor nodes from a power consumption perspective and discuss how decisions taken during node design can significantly impact the system energy consumption. The system architecture of a canonical wireless sensor node is shown in Fig. 1.

The node is comprised of four subsystems: i) a computing subsystem consisting of a microprocessor or microcontroller, ii) a communication subsystem consisting of a short range radio for wireless communication, iii) a sensing subsystem that links the node to the physical world and consists of a group of sensors and actuators, and iv) a power supply subsystem, which houses the battery and the dc-dc converter, and powers the rest of the node. The sensor node shown in Fig. 1 is representative of commonly used node architectures such as [1] and [2].

2.a .Microcontroller Unit:

Providing intelligence to the sensor node, the microcontroller unit (MCU) is responsible for control of the sensors and the execution of communication protocols and signal processing algorithms on the gathered sensor data. Commonly used MCUs are Intel's Strong ARM microprocessor and Atmel's AVR microcontroller. The power-performance characteristics of MCUs have been studied extensively, and several techniques have been proposed to estimate the power consumption of these embedded processors [7], [8]. While the choice of MCU is dictated by the required performance levels, it can also significantly impact the node's power dissipation characteristics.For example, the StrongARM microprocessor from Intel, used in high-end sensor nodes, consumes around 400 mW of power while executing instructions,whereas the ATmega103L AVR microcontroller from Atmel consumes only around 16.5 mW, but provides much lower performance.

3. HARDWARE DESIGN ISSUES

In a generic sensor node (Figure 3), we can identify a power module, a communication block, a processing unit with internal and/or external memory, and a module for sensing and actuation.

Power

Using stored energy or harvesting energy from the outside world are the two options for the power module. Energy storage may be achieved with the use of batteries or alternative devices such as fuel cells or miniaturized heat engines, whereas energy-scavenging opportunities [D37] are provided by solar power, vibrations, acoustic noise, and piezoelectric effects [D38]. The vast majority of the existing commercial and research platforms relies on batteries, which dominate the node size. Primary (nonrechargeable) batteries are often chosen, predominantly AA, AAA and coin-type.

Alkaline batteries offer a high energy density at a cheap price, offset by a non-flat discharge,a large physical size with respect to a typical sensor node,and a shelf life of only 5 years. Voltage regulation could in principle be employed, but its high inefficiency and large quiescent current consumption call for the use of components that can deal with large variations in the supply voltage [A5]. Lithium cells are very compact and boast a flat discharge curve. Secondary (rechargeable) batteries are typically not desirable, as they offer a lower energy density and a higher cost, not to mention the fact that in most applications recharging is simply not practical.

Fuel cells [D39] are rechargeable electrochemical energy-conversion devices where electricity and heat are produced as long as hydrogen is supplied to react with oxygen. Pollution is minimal, as water is the main byproduct of the reaction. The potential of fuel cells for energy storage and power delivery is much higher than the one of traditional battery technologies, but the fact that they require hydrogen complicates their application. Using renewable energy and scavenging techniques is an interesting alternative

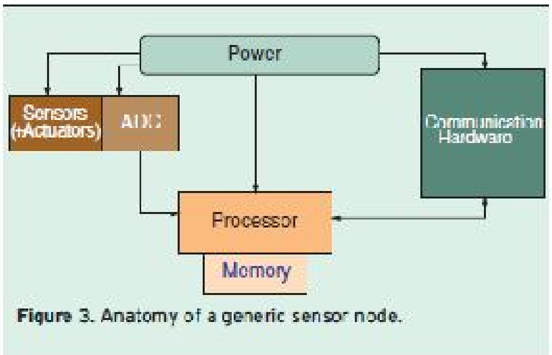

Figure 1. Anatomy of a generic sensor node.

4. CLUSTERING:

If the number of nodes used in the application is large, then data aggregation has to be done. If all the nodes try to send the sensed data to the BS(Base Station), more energy will be consumed,eventually more nodes will die frequently. The data gathered by a set of nodes has to aggregated and sent to the BS from that point. A tree like arrangement of wireless sensor nodes is used in this work. All the nearby nodes are grouped to form different clusters. This idea is inspired from the work of LEACH [13] (Low Energy Adaptive Clustering Hierarchy). In this algorithm, different set of nodes become the cluster heads each time. Every time the node which is the cluster head takes the responsibility of aggregating the data from its nearby nodes and sends the data to the BS, there by reduces the energy wastage of all the nodes. There are also other types of routing techniques available. Most of them are derived from the LEACH [13]. The other types are Random walk [15] protocol-In this the nodes are simply arranged like a grid.

The nodes are assumed to be present at the grid junctions, and then the desired route is found out. There are again three more subdivision under these. But practically for the environmental monitoring applications, this type of keeping the nodes at grid junction i.e., the topology becomes impossible. In Directed Diffusion method [14], the query will be broadcasted from the node, it will reach only the active (alive) nodes. The interested nodes will then send back the data to the desired node. In turn this will lead to lot of energy wastage, since broadcasting needs lot of energy.So the cluster based routing is best suitable routing protocol for Environmental monitoring applications.

In this work, the clusters are formed based on a weight attached to each node. While forming the clusters, the following rule should be followed- No two clusters should have one or more nodes in interference range. Interference range is that , the two nearest nodes in two different clusters should not be in either transmitting(rt)or receiving state(rr). This will cause interference and overhearing of packets and thereby wastage of energy.

5. SIMULATION AND RESULTS:

The above described method of Cluster based sleep/wake-up scheduling is tested in a simulated WSN and it proves to be efficient. Network Simulator-2(NS2) is used in this work for simulation.NS2 is one of the best simulation tools available for Wireless sensor Networks. We can easily implement the designed protocols either by using the otcl coding or by writing the C++ Program. In either way , the tool helps to prove our theory analytically.

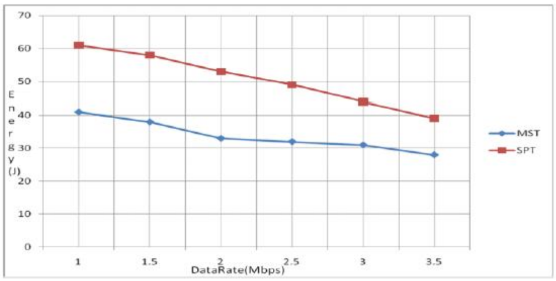

Figure 2. simulation results of sensor node.

6. COCLUSION:

Sensor networks offer countless challenges, but their versatility and their broad range of applications are eliciting more and more interest from the research community as well as from industry. Sensor networks have the potential of triggering the next revolution in information technology The challenges in terms of circuits and systems are numerous: the development of low-power communication hardware, low-power microcontrollers, MEMS based sensors and actuators, efficient AD conversion, and energy-scavenging devices is necessary to enhance the potential and the performance of sensor networks. System integration is another major challenge that sensor networks offer to the circuits and systems research community. We believe that CAS can and should have a significant impact in this emerging, exciting area.

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